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GE Power Systems

SPEEDTRONIC™ Mark VI Turbine Control System

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SPEEDTRONIC™ Mark VI Turbine Control System

Introduction

The SPEEDTRONIC™ Mark VI turbine control is the current state-of-the-art control for GE turbines that have a heritage of more than 30 years of successful operation. It is designed as a complete integrated control, protection, and monitoring system for generator and mechanical drive applications of gas and steam turbines. It is also an ideal platform for integrating all power island and balance-of-plant controls. Hardware and software are designed with close coordination between GE's turbine design engineering and controls engineering to insure that your control system provides the optimum turbine performance and you receive a true "system" solution. With Mark VI, you receive the benefits of GE's unmatched experience with an advanced turbine control platform. (*See Figure 1.*)

- Over 30 years experience
- Complete control, protection, and monitoring
- Can be used in variety of applications
- Designed by GE turbine and controls engineering

Figure 1. Benefits of Speedtronic™ Mark VI

Architecture

The heart of the control system is the Control Module, which is available in either a 13- or 21-slot standard VME card rack. Inputs are received by the Control Module through termination boards with either barrier or box-type terminal blocks and passive signal conditioning.

Each I/O card contains a TMS320C32 DSP processor to digitally filter the data before conversion to 32 bit IEEE-854 floating point format. The data is then placed in dual port memory that is accessible by the on-board C32 DSP on one side and the VME bus on the other.

In addition to the I/O cards, the Control Module contains an "internal" communication card, a main processor card, and sometimes a flash disk card. Each card takes one slot except for the main processor that takes two slots. Cards are manufactured with surface-mounted technology and conformal coated per IPC-CC-830.

I/O data is transmitted on the VME backplane between the I/O cards and the VCMI card located in slot 1. The VCMI is used for "internal" communications between:

- I/O cards that are contained within its card rack
- I/O cards that may be contained in expansion I/O racks called Interface Modules
- I/O in backup <P> Protection Modules
- I/O in other Control Modules used in triple redundant control configurations
- The main processor card

The main processor card executes the bulk of the application software at 10, 20, or 40 ms depending on the requirements of the application. Since most applications require that spe-

cific parts of the control run at faster rates (i.e. servo loops, pyrometers, etc.), the distributed processor system between the main processor and the dedicated I/O processors is very important for optimum system performance. A QNX operating system is used for real-time applications with multi-tasking, priority-driven preemptive scheduling, and fast-context switching.

Communication of data between the Control Module and other modules within the Mark VI control system is performed on IONet. The VCMI card in the Control Module is the IONet bus master communicating on an Ethernet 10Base2 network to slave stations. A unique poling type protocol (Asynchronous Drives Language) is used to make the IONet more deterministic than traditional Ethernet LANs. An optional Genius Bus™ interface can be provided on the main processor card in Mark VI Simplex controls for communication with the GE Fanuc family of remote I/O blocks. These blocks can be selected with the same software configuration tools that select Mark VI I/O cards, and the data is resident in the same database.

The Control Module is used for control, protection, and monitoring functions, but some applications require backup protection. For example, backup emergency overspeed protection is always provided for turbines that do not have a mechanical overspeed bolt, and backup synch check protection is commonly provided for generator drives. In these applications, the IONet is extended to a Backup Protection Module that is available in Simplex and triple redundant forms. The triple redundant version contains three independent sections (power supply, processor, I/O) that can be replaced while the turbine is running. IONet is used to access diagnostic data or for cross-tripping between the Control Module and the Protection Module, but it is not required for tripping.

Triple Redundancy

Mark VI control systems are available in Simplex and Triple Redundant forms for small applications and large integrated systems with control ranging from a single module to many distributed modules. The name Triple Module Redundant (TMR) is derived from the basic architecture with three completely separate and independent Control Modules, power supplies, and IONets. Mark VI is the third generation of triple redundant control systems that were pioneered by GE in 1983. System throughput enables operation of up to nine, 21-slot VME racks of I/O cards at 40 ms including voting the data. Inputs are voted in software in a scheme called Software Implemented Fault Tolerance (SIFT). The VCMI card in each Control Module receives inputs from the Control Module back-plane and other modules via “its own” IONet.

Data from the VCMI cards in each of the three Control Modules is then exchanged and voted prior to transmitting the data to the main processor cards for execution of the application software. Output voting is extended to the turbine with three coil servos for control valves and 2 out of 3 relays for critical outputs such as hydraulic trip solenoids. Other forms of output voting are available, including a median select of 4-20ma outputs for process control and 0-200ma outputs for positioners.

Sensor interface for TMR controls can be either single, dual, triple redundant, or combinations of redundancy levels. The TMR architecture supports riding through a single point failure in the electronics and repair of the defective card or module while the process is running. Adding sensor redundancy increases the fault tolerance

of the overall "system." Another TMR feature is the ability to distinguish between field sensor faults and internal electronics faults. Diagnostics continuously monitor the 3 sets of input electronics and alarms any discrepancies between them as an internal fault versus a sensor fault. In addition, all three main processors continue to execute the correct "voted" input data. (*See Figure 2.*)

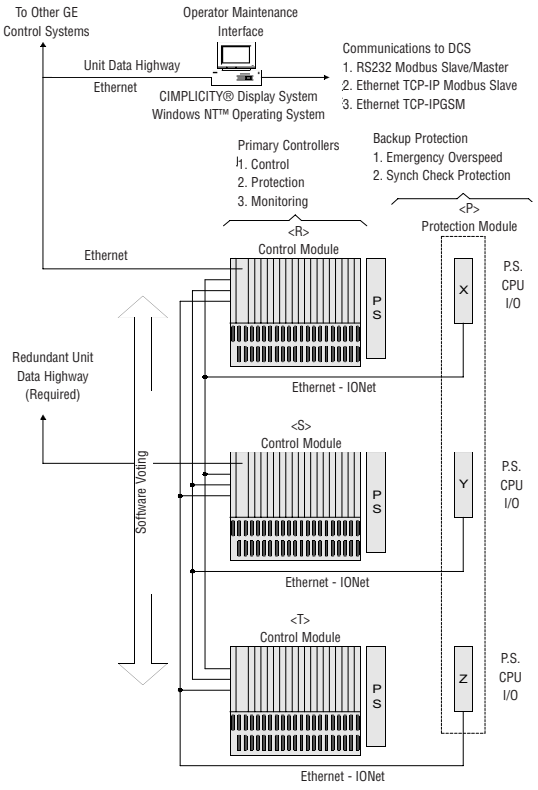

Figure 2. Mark VI TMR control configuration

I/O Interface

There are two types of termination boards. One type has two 24-point, barrier-type terminal blocks that can be unplugged for field maintenance. These are available for Simplex and TMR controls. They can accept two 3.0 mm^2 (#12AWG) wires with 300 volt insulation. Another type of termination board used on Simplex controls is mounted on a DIN rail and has one, fixed, box-type terminal block. It can accept one 3.0 mm^2 (#12AWG) wire or two 2.0 mm^2 (#14AWG) wires with 300 volt insulation.

I/O devices on the equipment can be mounted up to 300 meters (984 feet) from the termination boards, and the termination boards must be within 15 m (49.2') from their corresponding I/O cards. Normally, the termination boards are mounted in vertical columns in termination cabinets with pre-assigned cable lengths and routing to minimize exposure to emi-rfi for noise sensitive signals such as speed inputs and servo loops.

General Purpose I/O

Discrete I/O. A VCRC card provides 48 digital inputs and 24 digital outputs. The I/O is divided between 2 Termination Boards for the contact inputs and another 2 for the relay outputs. (*See Table 1.*)

Analog I/O. A VAIC card provides 20 analog inputs and 4 analog outputs. The I/O is divided between 2 Termination Boards. A VAOC is dedicated to 16 analog outputs and interfaces with 1 barrier-type Termination Board or 2 box-type Termination Boards. (*See Table 2.*)

Temperature Monitoring. A VTCC card provides interface to 24 thermocouples, and a VRTD card provides interface for 16 RTDs. The input cards interface with 1 barrier-type

TB	Type	I/O	Characteristics
TBCI	Barrier	24 CI	70-145Vdc, optical isolation, 1ms SOE 2.5ma/point except last 3 input are 10ma / point
DTCI	Box	24 CI	18-32Vdc, optical isolation, 1ms SOE 2.5ma/point except last 3 input are 10ma/point
TICI	Barrier	24 CI	70-145Vdc, 200-250Vdc, 90-132Vrms, 190-264Vrms (47-63Hz), optical isolation 1ms SOE, 3ma / point
TRLY	Barrier	12 CO	Plug-in, magnetic relays, dry, form "C" contacts 6 circuits with fused 3.2A, suppressed solenoid outputs Form H1B: diagnostics for coil current Form H1C: diagnostics for contact voltage Voltage Resistive Inductive 24Vdc 3.0A 3.0 amps L/R = 7 ms, no suppr. 3.0 amps L/R = 100 ms, with suppr 125Vdc 0.6A 0.2 amps L/R = 7 ms, no suppr. 0.6 amps L/R = 100 ms, with suppr 120/240Vac 6/3A 2.0 amps pf = 0.4
DRLY	Box	12 CO	Same as TRLY, but no solenoid circuits

Table 1. Discrete I/O

TB	Type	I/O	Characteristics
TBAI	Barrier	10 AI 2 AO	(8) 4-20ma (250 ohms) or +/-5,10Vdc inputs (2) 4-20ma (250 ohms) or +/-1ma (500 ohms) inputs Current limited +24Vdc provided per input (2) +24V, 0.2A current limited power sources (1) 4-20ma output (500 ohms) (1) 4-20ma (500 ohms) or 0-200ma (50 ohms) output
TBAO	Barrier	16 AO	(16) 4-20ma outputs (500 ohms)
DTAI	Box	10 AI 2 AO	(8) 4-20ma (250 ohms) or +/-5,10Vdc inputs (2) 4-20ma (250 ohms) or +/-1ma (500 ohms) inputs Current limited +24Vdc available per input (1) 4-20ma output (500 ohms) (1) 4-20ma (500 ohms) or 0-200ma (50 ohms) output
DTAO	Box	8 AO	(8) 4-20ma outputs (500 ohms)

Table 2. Analog I/O

Termination Board or 2 box-type Termination Boards. Capacity for monitoring 9 additional thermocouples is provided in the Backup Protection Module. (*See Table 3.*)

TB	Type	I/O	Characteristics
TBTC	Barrier	24 TC	Types: E, J, K, T, grounded or ungrounded H1A fanned (paralleled) inputs, H1B dedicated inputs
DTTC	Box	12 TC	Types: E, J, K, T, grounded or ungrounded
TRTD	Barrier	16 RTD	3 points/RTD, grounded or ungrounded 10 ohm copper, 100/200 ohm platinum, 120 ohm nick H1A fanned (paralleled) inputs, H1B dedicated inputs
DTAI	Box	8 RTD	RTDs, 3 points/RTD, grounded or ungrounded 10 ohm copper, 100/200 ohm platinum, 120 ohm nick

Table 3. Temperature Monitoring

Application Specific I/O

In addition to general purpose I/O, the Mark VI has a large variety of cards that are designed for direct interface to unique sensors and actuators. This reduces or eliminates a substantial amount of interposing instrumentation in many applications. As a result, many potential single-point failures are eliminated in the most critical area for improved running reliability and reduced long-term maintenance. Direct interface to the sensors and actuators also enables the diagnostics to directly interrogate the devices on the equipment for maximum effectiveness. This data is used to analyze device and system performance. A subtle benefit of this design is that spare-parts inventories are reduced by eliminating peripheral instrumentation. The VTUR card is designed to integrate several of the unique sensor interfaces used in turbine control systems on a single card. In some applications, it works in conjunction with the I/O interface in the Backup Protection Module described below.

Speed (Pulse Rate) Inputs. Four-speed inputs from passive magnetic sensors are monitored by the VTUR card. Another two-speed (pulse rate) inputs can be monitored by the servo card VSVO which can interface with either passive or active speed sensors. Pulse rate inputs on the VSVO are commonly used for flow-divider feedback in servo loops. The frequency range is 2-14k Hz with sufficient sensitivity at 2 Hz to detect zero speed from a 60-toothed wheel. Two additional passive speed sensors can be monitored by "each" of the three sections of the Backup Protection Module used for emergency overspeed protection on turbines that do not have a mechanical overspeed bolt. IONet is used to communicate diagnostic and process data between the Backup Protection Module and the Control Module(s) including cross-tripping capability; however, both modules will initiate system trips independent of the IONet. (*See Table 4 and Table 5.*)

Synchronizing. The synchronizing system consists of automatic synchronizing, manual synchronizing, and backup synch check protection. Two single-phase PT inputs are provided

TB	Type	I/O	Characteristics
TTUR	Barrier	4 Pulse rate 2 PTs Synch relays 2 SVM	Passive magnetic speed sensors (2-14k Hz) Single phase PTs for synchronizing Auto/Manual synchronizing interface Shaft voltage / current monitor
TRPG* TRPS* TRPL*	Barrier	3 Trip solenoids 8 Flame inputs	(-) side of interface to hydraulic trip solenoids UV flame scanner inputs (Honeywell)
DTUR	Box	4 Pulse Rate	Passive magnetic speed sensors (2-14k Hz)
DRLY DTRT	Box	12 Relays	Form "C" contacts – previously described Transition board between VTUR & DRLY

Table 4. VTUR I/O terminations from Control Module

TB	Type	I/O	Characteristics
TPRO	Barrier	9 Pulse rate	Passive magnetic speed sensors (2-14k Hz)
		2 PTs	Single phase PTs for backup synch check
		3 Analog inputs	(1) 4-20ma (250 ohm) or +/-5,10Vdc inputs
			(2) 4-20ma (250 ohm)
		9 TC inputs	Thermocouples, grounded or ungrounded
TREG*	Barrier	3 Trip solenoids	(+) side of interface to hydraulic trip solenoids
TRES*		8 Trip contact in	1 E-stop (24Vdc) & 7 Manual trips (125Vdc)
TREL*			

Table 5. VPRO I/O terminations from Backup Protection Module

on the TTUR Termination Board to monitor the generator and line busses via the VTUR card. Turbine speed is matched to the line frequency, and the generator and line voltages are matched prior to giving a command to close the breaker via the TTUR.

An external synch check relay is connected in series with the internal K25P synch permissive relay and the K25 auto synch relay via the TTUR. Feedback of the actual breaker closing time is provided by a 52G/a contact from the generator breaker (not an auxiliary relay) to update the database. An internal K25A synch check relay is provided on the TTUR; however, the backup phase / slip calculation for this relay is performed in the Backup Protection Module or via an external backup synch check relay. Manual synchronizing is available from an operator station on the network or from a synchroscope.

Shaft Voltage and Current Monitor. Voltage can build up across the oil film of bearings until a discharge occurs. Repeated discharge and arcing can cause a pitted and roughened bearing surface that will eventually fail through accelerated mechanical wear. The VTUR / TTUR can continuously monitor the shaft-to- ground voltage and current, and alarm at excessive levels. Test circuits are provided to check the alarm functions and the continuity of wiring to the brush assembly that is mounted between the turbine and the generator.

Flame Detection. The existence of flame either can be calculated from turbine parameters that are already being monitored or from a direct interface to Reuter Stokes or Honeywell-type flame detectors. These detectors monitor the flame in the combustion chamber by detecting UV radiation emitted by the flame. The Reuter Stokes detectors produce a 4-20ma input. For Honeywell flame scanners, the Mark VI supplies the 335Vdc excitation and the VTUR / TRPG monitors the pulses of current being generated. This determines if carbon buildup or other contaminates on the scanner window are causing reduced light detection.

Trip System. On turbines that do not have a mechanical overspeed bolt, the control can issue a trip command either from the main processor card to the VTUR card in the Control Module(s) or from the Backup Protection Module. Hydraulic trip solenoids are wired with the negative side of the 24Vdc/125Vdc circuit connected to the TRPG, which is driven from the VTUR in the Control Module(s) and the positive side connected to the TREG which is driven from the VPRO in each section of the Backup Protection Module. A typical system trip initiated in the Control Module(s) will cause the analog control to drive the servo valve actuators closed, which stops fuel or steam flow and de-energizes (or energizes) the hydraulic trip solenoids from the VTUR and TRPG. If cross-tripping is used or an overspeed condition is detected, then the VTUR/TRPG will trip one side of the solenoids and the VPTRO/TREG will trip the other side of the solenoid(s).

Servo Valve Interface. A VSVO card provides 4 servo channels with selectable current drivers, feedback from LVDTs, LVDRs, or ratio metric LVDTs, and pulse-rate inputs from flow divider feedback used on some liquid fuel systems. In TMR applications, 3 coil servos are commonly

used to extend the voting of analog outs to the servo coils. Two coil servos can also be used. One, two, or three LVDT/Rs feedback sensors can be used per servo channel with a high select, low select, or median select made in software. At least 2 LVDT/Rs are recommended for TMR applications because each sensor requires an AC excitation source. (*See Table 6 and Table 7.*)

TB	Type	I/O	Characteristics
TSVO	Barrier	2 chnls.	(2) Servo current sources (6) LVDT/LVDR feedback 0 to 7.0 Vrms (4) Excitation sources 7 Vrms, 3.2k Hz (2) Pulse rate inputs (2-14k Hz) *only 2 per VSVO
DSVO	Box	2 chnls.	(2) Servo current sources (6) LVDT/LVDR feedback 0 to 7.0 Vrms (2) Excitation sources 7 Vrms, 3.2k Hz (2) Pulse rate inputs (2-14k Hz) *only 2 per VSVO

Table 6. VSVO I/O terminations from Control Module

Coil Type	Nominal Current	Coil Resistance	Mark VI Control
#1	+/- 10 ma	1,000 ohms	Simplex & TMR
#2	+/- 20 ma	125 ohms	Simplex
#3	+/- 40 ma	62 ohms	Simplex
#4	+/- 40 ma	89 ohms	TMR
#5	+/- 80 ma	22 ohms	TMR
#6	+/- 120 ma	40 ohms	Simplex
#7	+/- 120 ma	75 ohms	TMR

Table 7. Nominal servo valve ratings

Vibration / Proximitor® Inputs. The VVIB card provides a direct interface to seismic (velocity), Proximitor®, Velomitor®, and accelerometer (via charge amplifier) probes. In addition, DC position inputs are available for axial measurements and Keyphasor® inputs are provided. Displays show the 1X and unfiltered vibration levels and the 1X vibration phase angle. -24vdc is supplied from the control to each Proximitor with current limiting per point. An optional termination board can be provided with active isolation amplifiers to buffer the sensor signals from BNC connectors. These connectors can be used to access real-time data by remote vibration analysis equipment. In addition, a direct plug connection is available from the termination board to a Bently Nevada 3500 monitor. The 16 vibration inputs, 8 DC position inputs, and 2 Keyphasor inputs on the VVIB are divided between 2 TVIB termination boards for 3,000 rpm and 3,600 rpm applications. Faster shaft speeds may require faster sampling rates on the VVIB processor, resulting in reduced vibration inputs from 16-to-8. (*See Table 8.*)

TB	Type	I/O	Characteristics
TVIB	Barrier	8 Vibr. 4 Pos. 1 KP	Seismic, Proximitor, Velomitor, accelerometer charge amplifier DC inputs Keyphasor Current limited –24Vdc provided per probe

Table 8. VVIB I/O terminations from Control Module

Three phase PT and CT monitoring. The VGEN card serves a dual role as an interface for 3 phase PTs and 1 phase CTs as well as a specialized control for Power-Load Unbalance and Early-Valve Actuation on large reheat steam turbines. The I/O interface is split between the TGEN Termination Board for the PT and CT inputs and the TRLY Termination Board for relay outputs to the fast acting solenoids. 4-20ma inputs are also provided on the TGEN for monitoring pressure transducers. If an EX2000 Generator Excitation System is controlling the generator, then 3 phase PT and CT data is communicated to the Mark VI on the network rather than using the VGEN card. (*See Table 9.*)

Optical Pyrometer Inputs. The VPYR card moni-

TB	Type	I/O	Characteristics
TGEN	Barrier	2 PTs	3 Phase PTs, 115Vrms 5-66 Hz, 3 wire, open delta
		3 CTs	1 Phase CTs, 0-5A (10A over range) 5-66 Hz
		4 AI	4-20ma (250 ohms) or +/-5,10Vdc inputs Current limited +24Vdc/input
TRLY	Barrier	12 CO	Plug-in magnetic relays previously described

Table 9. VGEN I/O terminations from Control Module

tors two LAND infrared pyrometers to create a temperature profile of rotating turbine blades. Separate, current limited +24Vdc and –24Vdc sources are provided for each Pyrometer that returns four 4-20ma inputs. Two Keyphasors are used for the shaft reference. The VPYR and matching TPYR support 5,100 rpm shaft speeds and can be configured to monitor up to 92 buckets with 30 samples per bucket. (*See Table 10.*)

TB	Type	I/O	Characteristics
TPYR	Barrier	2 Pyrometers	(8) 4-20ma (100 ohms) (2) Current limited +24Vdc sources (2) Current limited -24Vdc sources (2) Keyphasor inputs

Table 10. VPYR I/O terminations from Control Module

Operator Interface

The operator interface is commonly referred to as the Human Machine Interface (HMI). It is a PC with a Microsoft® Windows NT® operating system supporting client/server capability, a CIMPLICITY® graphics display system, a Control System Toolbox for maintenance, and a software interface for the Mark VI and other control systems on the network. (*See Figure 3.*) It can be applied as:

- The primary operator interface for one or multiple units
- A backup operator interface to the plant DCS operator interface
- A gateway for communication links to other control systems
- A permanent or temporary maintenance station
- An engineer's workstation

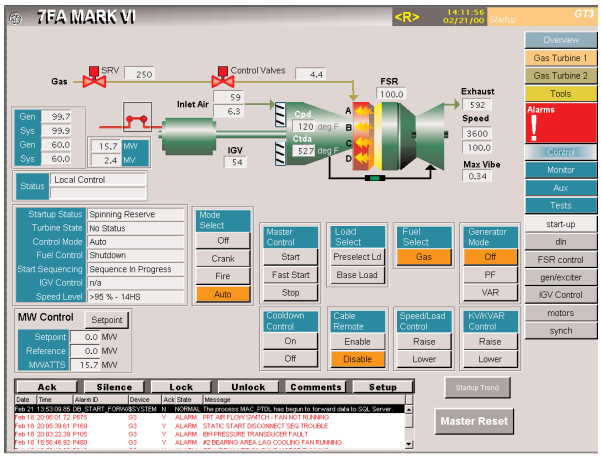

Figure 3. Operator interface graphics: 7FA Mark VI

All control and protection is resident in the Mark VI control, which allows the HMI to be a non-essential component of the control system. It can be reinitialized or replaced with the process running with no impact on the control system. The HMI communicates with the main processor card in the Control Module via the Ethernet based Unit Data Highway (UDH). All analog and digital data in the Mark VI is accessible for HMI screens including the high resolution time tags for alarms and events.

System (process) alarms and diagnostics alarms for fault conditions are time tagged at frame rate (10/20/40 ms) in the Mark VI control and transmitted to the HMI alarm management system. System events are time tagged at frame rate, and Sequence of Events (SOE) for contact inputs are time tagged at 1ms on the contact input card in the Control Module. Alarms can

be sorted according to ID, Resource, Device, Time, and Priority. Operators can add comments to alarm messages or link specific alarm messages to supporting graphics.

Data is displayed in either English or Metric engineering units with a one-second refresh rate and a maximum of one second to repaint a typical display graphic. Operator commands can be issued by either incrementing / decrementing a setpoint or entering a numerical value for the new setpoint. Responses to these commands can be observed on the screen one second from the time the command was issued. Security for HMI users is important to restrict access to certain maintenance functions such as editors and tuning capability, and to limit certain operations. A system called "User Accounts" is provided to limit access or use of particular HMI features. This is done through the Windows NT User Manager administration program that supports five user account levels.

Software Maintenance Tools

The Mark VI is a fully programmable control system. Application software is created from in-house software automation tools which select proven GE control and protection algorithms and integrate them with the I/O, sequencing, and displays for each application. A library of software is provided with general-purpose blocks, math blocks, macros, and application specific blocks. It uses 32-bit floating point data (IEEE-854) in a QNX operating system with real-time applications, multitasking, priority-driven preemptive scheduling, and fast context switching.

Software frame rates of 10, 20, and 40 ms are supported. This is the elapsed time that it takes to read inputs, condition the inputs, execute the application software, and send outputs. Changes to the application software can be made with password protection (5 levels) and downloaded to the Control Module while the process is running. All application software is stored in the Control Module in non-volatile flash memory.

Application software is executed sequentially and represented in its dynamic state in a ladder diagram format. Maintenance personnel can add, delete, or change analog loops, sequencing logic, tuning constants, etc. Data points can be selected and "dragged" on the screen from one block to another to simplify editing. Other features include logic forcing, analog forcing, and trending at frame rate. Application software documentation is created directly from the source code and printed at the site. This includes the primary elementary diagram, I/O assignments, the settings of tuning constants, etc. The software maintenance tools (Control System Toolbox) are available in the HMI and as a separate software package for virtually any Windows 95 or NT based PC. The same tools are used for EX2000 Generator Excitation Systems, and Static Starters. (*See Figure 4 and Figure 5.*)

Communications

Communications are provided for internal data transfer within a single Mark VI control; communications between Mark VI controls and peer GE control systems; and external communications to remote systems such as a plant distributed control system (DCS).

The Unit Data Highway (UDH) is an Ethernet-based LAN with peer-to-peer communication between Mark VI controls, EX2000 Generator Excitation Controls, Static Starters, the GE Fanuc family of PLC based controls, HMIs, and Historians. The network uses Ethernet Global Data (EGD) which is a message-based protocol with support for sharing information with mul-

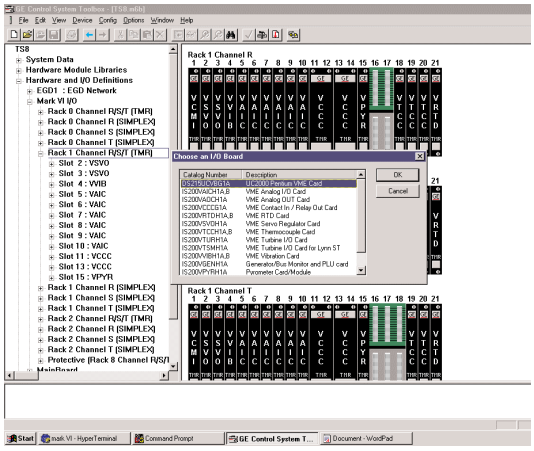

Figure 4. Software maintenance tools – card configuration

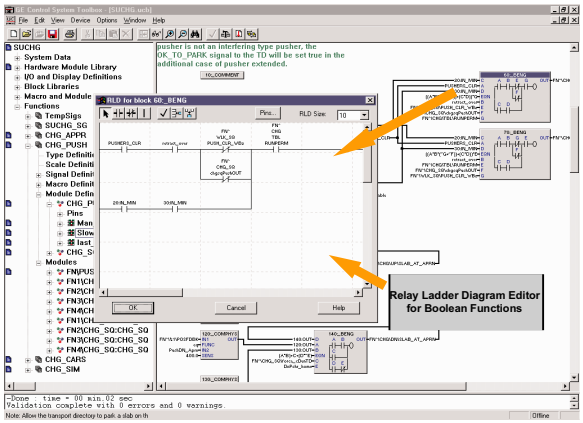

Figure 5. Software maintenance tools – editors

tiple nodes based on the UDP/IP standard (RFC 768). Data can be transmitted Unicast, Multicast or Broadcast to peer control systems. Data (4K) can be shared with up to 10 nodes at 25Hz (40ms). A variety of other proprietary protocols are used with EGD to optimize communication performance on the UDH.

40 ms is fast enough to close control loops on the UDH; however, control loops are normally closed within each unit control. Variations of this exist, such as transmitting setpoints between turbine controls and generator controls for voltage matching and var/power-factor control. All trips between units are hardwired even if the UDH is redundant.

The UDH communication driver is located on the Main Processor Card in the Mark VI. This is the same card that executes the turbine application software; therefore, there are no potential communication failure points between the main turbine processor and other controls or monitoring systems on the UDH. In TMR systems, there are three separate processor cards executing identical application software from identical databases. Two of the UDH drivers are normally connected to one switch, and the other UDH driver is connected to the other switch in a star configuration. Network topologies conform to Ethernet IEEE 802.3 standards.

The GE networks are a Class "C" Private Internet according to RFC 1918: Address Allocation for Private Internets – February 1996. Internet Assigned Numbers Authority (IANA) has reserved the following IP address space 192.168.1.1: 192.168.255.255 (192.168/16 prefix).

Communication links from the Mark VI to remote computers can be implemented from either an optional RS232 Modbus port on the main processor card in Simplex systems, or from a variety of communication drivers from the HMI. When the HMI is used for the communication interface, an Ethernet card in the HMI provides an interface to the UDH, and a second Ethernet card provides an interface to the remote computer.

All operator commands that can be issued from an HMI can be issued from a remote computer through the HMI(s) to the Mark VI(s), and the remote computer can monitor any application software data in the Mark VI(s). Approximately 500 data points per control are of interest to a plant control system; however, about 1,200

points are commonly accessed through the communication links to support programming screen attributes such as changing the color of a valve when it opens.

Communication Link Options

Communication link options include:

- An RS-232 port with Modbus Slave RTU or ASCII communications from the Main Processor Card. (Simplex: full capability. TMR: monitor data only – no commands)
- An RS-232 port with Modbus Master / Slave RTU protocol is available from the HMI.
- An RS-232/485 converter (half-duplex) can be supplied to convert the RS-232 link for a multi-drop network.
- Modbus protocol can be supplied on an Ethernet physical layer with TCP-IP for faster communication rates from the HMI.
- Ethernet TCP-IP can be supplied with a GSM application layer to support the transmission of the local high-resolution time tags in the control to a DCS from the HMI. This link offers spontaneous transmission of alarms and events, and common request messages that can be sent to the HMI including control commands and alarm queue commands. Typical commands include momentary logical commands and analog "setpoint target" commands. Alarm queue commands consist of silence (plant alarm horn) and reset commands as well as alarm dump requests that cause the entire alarm queue to be transmitted from the Mark VI to the DCS.
- Additional "master" communication drivers are available from the HMI.

Time Synchronization

Time synchronization is available to synchronize all controls and HMIs on the UDH to a Global Time Source (GTS). Typical GTSs are Global Positioning Satellite (GPS) receivers such as the StarTime GPS Clock or other time-processing hardware. The preferred time sources are Universal Time Coordinated (UTC) or GPS; however, the time synchronization option also supports a GTS using local time as its base time reference. The GTS supplies a time-link network to one or more HMIs with a time/frequency processor board. When the HMI receives the time signal, it is sent to the Mark VI(s) using Network Time Protocol (NTP) which synchronizes the units to within +/-1ms time coherence. Time sources that are supported include IRIG-A, IRIG-B, 2137, NASA-36, and local signals.

Diagnostics

Each circuit card in the Control Module contains system (software) limit checking, high/low (hardware) limit checking, and comprehensive diagnostics for abnormal hardware conditions. System limit checking consists of 2 limits for every analog input signal, which can be set in engineering units for high/high, high/low, or low/low with the I/O Configurator. In addition, each input limit can be set for latching/non-latching and enable/disable. Logic outputs from system limit checking are generated per frame and are available in the database (signal space) for use in control sequencing and alarm messages.

High/low (hardware) limit checking is provided on each analog input with typically 2 occurrences required before initiating an alarm. These limits are not configurable, and they are

selected to be outside the normal control requirements range but inside the linear hardware operational range (before the hardware reaches saturation). Diagnostic messages for hardware limit checks and all other hardware diagnostics for the card can be accessed with the software maintenance tools (Control System Toolbox). A composite logic output is provided in the data base for each card, and another logic output is provided to indicate a high/low (hardware) limit fault of any analog input or the associated communications for that signal.

The alarm management system collects and time stamps the diagnostic alarm messages at frame rate in the Control Module and displays the alarms on the HMI. Communication links to a plant DCS can contain both the software (system) diagnostics and composite hardware diagnostics with varying degrees of capability depending on the protocol's ability to transmit the local time tags. Separate manual reset commands are required for hardware and system (software) diagnostic alarms assuming that the alarms were originally designated as latching alarms, and no alarms will reset if the original cause of the alarm is still present.

Hardware diagnostic alarms are displayed on the yellow "status" LED on the card front. Each card front includes 3 LEDs and a reset at the top of the card along with serial and parallel ports. The LEDs include: RUN: Green; FAIL: Red; STATUS: Yellow.

Each circuit card and termination board in the system contains a serial number, board type, and hardware revision that can be displayed; 37 pin "D" type connector cables are used to interface between the Termination Boards and the J3 and J4 connectors on the bottom of the Control Module. Each connector comes with latching fasteners and a unique label identifying the correct termination point. One wire in each connector is dedicated to transmitting an identification message with a bar-code serial number, board type, hardware revision, and a connection location to the corresponding I/O card in the Control Module.

Power

In many applications, the control cabinet is powered from a 125Vdc battery system and short circuit protected external to the control. Both sides of the floating 125Vdc bus are continuously monitored with respect to ground, and a diagnostic alarm is initiated if a ground is detected on either side of the 125Vdc source.

When a 120/240vac source is used, a power converter isolates the source with an isolation transformer and rectifies it to 125Vdc. A diode high select circuit chooses the highest of the 125Vdc busses to distribute to the Power Distribution Module. A second 120/240vac source can be provided for redundancy. Diagnostics produce an under-voltage alarm if either of the AC sources drop below the under-voltage setting. For gas turbine applications, a separate 120/240vac source is required for the ignition transformers with short circuit protection of 20A or less.

The resultant "internal" 125Vdc is fuse-isolated in the Mark VI power distribution module and fed to the internal power supplies for the Control Modules, any expansion modules, and the termination boards for its field contact inputs and field solenoids. Additional 3.2A fuse protection is provided on the termination board TRLY for each solenoid. Separate 120Vac feeds are provided from the motor control center for any AC solenoids and ignition transformers on gas turbines. (*See Table 11.*)

Steady State Voltage	Freq.	Load	Comments
125Vdc (100 to 144Vdc)		10.0 A dc	Ripple <= 10V p-p Note 1
120vac (108 to 132vac)	47 - 63Hz	10.0 A rms	Harmonic distortion < 5% Note 2
240vac (200 to 264vac)	47 - 63 Hz	5.0 A rms	Harmonic distortion < 5 % Note 3

Table 11. Power requirements

Codes and Standards

ISO 9001 in accordance with Tick IT by Lloyd's Register Quality Assurance Limited. ISO 9000-3 Quality Management and Quality Assurance Standards, Part 3: Guidelines for the Application of ISO 9001 to Development Supply and Maintenance of Software.

Safety Standards

UL 508A Safety Standard Industrial Control Equip.

CSA 22.2 No. 14 Industrial Control Equipment

Printed Wire Board Assemblies

UL 796 Printed Circuit Boards

UL recognized PWB manufacturer,

UL file number E110691

ANSI IPC guidelines

ANSI IPC/EIA guidelines

CE - Electromagnetic Compatibility (EMC)

EN 50081-2
Generic Emissions Standards
EN 50082-2:1994
Generic Immunity Industrial Environment
EN 55011
Radiated and Conducted Emissions
IEC 61000-4-2:1995
Electrostatic Discharge Susceptibility
IEC 6100-4-3: 1997
Radiated RF Immunity
IEC 6100-4-4: 1995
Electrical Fast Transient Susceptibility
IEC 6100-4-5: 1995
Surge Immunity
IEC 61000-4-6: 1995
Conducted RF Immunity
IEC 61000-4-11: 1994
Voltage Variation, Dips, and Interruptions
ANSI/IEEE C37.90.1
Surge

CE - Low Voltage Directive

EN 61010-1
Electrical Equipment, Industrial Machines
IEC 529
Intrusion Protection Codes/NEMA 1/IP 20

Reference the Mark VI Systems Manual GEH-6421, Chapter 5 for additional codes and standards.

Environment

The control is designed for operation in an air-conditioned equipment room with convection cooling. Special cabinets can be provided for operation in other types of environments.

Temperature:

Operating	0° to +45°C	+32° to +113°F
Storage	-40° to +70°C	-40° to +158°F

The control can be operated at 50∞C during maintenance periods to repair air-conditioning systems. It is recommended that the electronics be operated in a controlled environment to maximize the mean-time-between-failure (MTBF) on the components.

Purchased commercial control room equipment such as PCs, monitors, and printers are typically capable of operating in a control room ambient of 0° to +40°C with convection cooling.

Humidity

5% to 95% non-condensing

Exceeds EN50178: 1994

Elevation

Exceeds EN50178: 1994

Gas Contaminants

EN50178: 1994 Section A.6.1.4 Table A.2 (m)

Dust Contaminants

Exceeds IEC 529: 1989-11 (IP-20)

Seismic Universal Building Code (UBC)

Section 2312 Zone 4

Documentation

The following documentation is available for Mark VI Turbine Controls. A subset of this documentation will be delivered with each control depending on the functional requirements of each system.

Manuals

- System Manual for SPEEDTRONICTM Mark VI Turbine Control (GEH-6421)
- Control System Toolbox, for Configuring a Mark VI Controller (GEH-6403)

  Configuring the Trend Recorder (GEH-6408)

  System Data Base for System Toolbox (GEI-100189)

  System Data Base Browser (GEI-100271)

  Data Historian (used for trip history) (GEI-100278)
- Communications To Remote Computers / Plant DCS

  RS232 Modbus Slave From Control Module

  Modbus Communications Implementation UCOC2000 - I/O Drivers, Chapter 2

  Communication Links From HMI:

  RS232 Modbus Master/Slave, Ethernet Modbus Slave, Ethernet TCP-IP GSM HMI

  SPEEDTRONIC™ Application Manual - Chapter 7 (GEH-6126), Ethernet TCP-IP GEDS Standard

  Message Format (GSM) (GEI-100165)
- Operator/Maintenance Interface HMI

  HMI for SPEEDTRONIC™ Turbine Controls

  Application Manual (GEH-6126)

  Cim Edit Operation Manual (GFK-1396)

  User Manual (GFK-1180)

  Cimplicity HMI For Windows NT Trending Operators

  Manual (GFK-1260)
- Turbine Historian System Guide (GEH-6421)
- Standard Blockware Library (SBLIB)
- Turbine Blockware Library (TURBLIB)

Drawings

- Equipment Outline Drawing AutoCAD R14
- Equipment Layout Drawing AutoCAD R14
- I/O Termination List (Excel Spreadsheet)
- Network one-line diagram (if applicable)
- Application Software Diagram (printout from source code)
- Data List For Communication Link To DCS

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